PROCESS SAFETY ASSESSMENT

OVERVIEW: The Process Safety Assessment module screens potential chemical substitutes to determine if they could potentially pose a safety hazard in the workplace. Process operating characteristics and workplace practices are combined with physical hazard data, precautions for safe handling and use, and other data to determine if implementing a chemical substitute might pose a safety hazard. Safe operating procedures for alternative technologies (equipment) are also considered.

GOALS:

- Obtain information on chemical hazards (reactivity, corrosivity, etc.), proper handling and storage precautions, and proper use guidelines for each chemical formulation or technology being evaluated.
- Compare physical hazard data to process operating conditions and workplace practices to determine if any of the chemical substitutes might pose a safety hazard in the workplace.
- Determine what special actions, if any, need to be taken when using substitute chemicals, formulations, or processes.
- Guide the selection and use of chemicals or processes that are less hazardous in the workplace.

PEOPLE SKILLS: The following lists the types of skills or knowledge that are needed to complete this module.

- Knowledge of chemicals used and/or produced by the process as well as knowledge and understanding of the technologies and equipment used for the process.
- Knowledge of the workplace practices and operating procedures for the given process.
- Knowledge of process safety analysis, Occupational Safety and Health Administration (OSHA) regulations, and guidelines pertaining to hazardous chemicals and industrial safety.

Within a business or a DFE project team, the people who might supply these skills include a process engineer, safety engineer, safety specialist, or an industrial hygienist.

DEFINITION OF TERMS: The Process Safety Assessment module focuses on physical hazards such as flammability and explosivity rather than health hazards from toxic chemical exposure. Health hazards are characterized in other parts of the CTSA. The definitions of

OSHA established limits for worker exposure to toxic chemicals (e.g., Permissible Exposure Limit and Threshold Limit Value) are listed in this module, however, to assist the individual in interpreting material safety data sheet data.

Combustible Liquid: As defined by OSHA (29 CFR 1910.1200), any liquid having a flash point at or above 140 °F (37.6 °C), but below 200 °F (93.3 °C), except any mixture having components with flashpoints of 200 °F (93.3 °C), or higher, the total volume of which makes up 99 percent or more of the total volume of the mixture.

Compressed Gas: As defined by OSHA (29 CFR 1910.1200):

- A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 °F (21.1 °C).
- A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 °F (54.4 °C) regardless of the pressure at 70 °F (21.1 °C).
- A liquid having a vapor pressure exceeding 40 psi at 100 °F (37.8 °C) as determined by ASTM D-323-72.

Corrosive: As defined by OSHA (29 CFR 1910.1200), a chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact. For example, a chemical is considered to be corrosive if, when tested on the intact skin of albino rabbits by the method described by the U.S. Department of Transportation in Appendix A to 49 CFR 173, it destroys or changes irreversibly the structure of the tissue at the site of contact following an exposure period of four hours. According to the OSHA definition, this term shall not refer to action on inanimate surfaces.

Explosive: As defined by OSHA (29 CFR 1910.1200), a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

Flammable: As defined by OSHA (29 CFR 1910.1200), a chemical that falls into one of the following categories:

- Flammable aerosol: An aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame projection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening.
- Flammable gas:
  - A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or
  - A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.
- Flammable liquid: Any liquid having a flashpoint below 100 °F (37.8 °C), except any mixture having components with flashpoints of 100 °F (37.8 °C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.
- Flammable solid: A solid, other than a blasting agent or explosive as defined in 29 CFR 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or

which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

Flash Point: As defined by OSHA (29 CFR 1910.1200), the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

- Tagliabue Closed Tester: (see American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24-1979 [ASTM D 56-79]) for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 ^{o}F (37.8 ^{o}C), that do not contain suspended solids and do not have a tendency to form a surface film under test.
- Pensky-Martens Closed Tester: (see American National Standard Method of Test for Flash Point by Pensky-Martens Closed Tester, Z11.7-1979 [ASTM D 93-79]) for liquids with a viscosity equal to or greater than 45 SUS at 100 ^{o}F (37.8 ^{o}C), or that contain suspended solids, or that have a tendency to form a surface film under test.
- Setaflash Closed Tester: (see American National Standard Method of Test for Flash Point by Setaflash Closed Tester [ASTM D 3278-78].) Typical units are ^{o}C or ^{o}F.

Hazard: A condition or changing set of circumstances that presents a potential for injury, illness, or property damage. The potential or inherent characteristics of an activity, condition, or circumstance which can produce adverse or harmful consequences. Hazards can be categorized into four groups: biological, chemical, mechanical, and physical.

Hazardous Chemical: As defined by OSHA (29 CFR 1910.1200), any chemical which is a physical hazard or a health hazard.

Hazardous Substance: Any substance which has the potential of causing injury by reason of its being explosive, flammable, toxic, corrosive, oxidizing, irritating, or otherwise harmful to personnel.

Immediately Dangerous to Life or Health (IDLH): The maximum inhalation level from which a worker could escape without any escape-impairing symptoms or any irreversible health effects.

Industrial Hygiene: The science and art devoted to the recognition, evaluation, and control of those environmental factors or stresses arising in or from work situations which may cause sickness, impaired health and well-being, or significant discomfort and inefficiency among workers or among the citizens of a community.

Irritant: As defined by OSHA (29 CFR 1910.1200), a chemical which is not corrosive but which causes a reversible, inflammatory effect on living tissue by chemical action at the site of contact. A chemical is a skin irritant if, when tested on the intact skin of albino rabbits by the methods of 16 CFR 1500.41 for four hours exposure or by other appropriate techniques, it results in an empirical score of five or more. A chemical is an eye irritant if so determined under the procedure listed in 16 CFR 1500.42 or other appropriate techniques.

Lower Explosive Limit (LEL): The minimum concentration of combustible gas or vapor in air below which propagation of flame does not occur on contact with a source of ignition. The lower limit of flammability of a gas or vapor at ordinary ambient temperatures expressed in percent of the gas or vapor in air by volume.

Material Safety Data Sheet (MSDS): As defined by OSHA (29 CFR 1910.1200), written or printed material concerning a hazardous material which contains the following:

- The identity of the hazardous material (except as provided for materials that are trade secrets).
- The physical and chemical characteristics of the hazardous chemical (such as vapor pressure, flash point).
- The physical hazards of the hazardous chemical, including the potential for fire, explosion, and reactivity.
- The health hazards of the hazardous chemical, including signs and symptoms of exposure, and any medical conditions which are generally recognized as being aggravated by exposure to the chemical.
- The primary route(s) of entry.
- The OSHA PEL, ACGIH Threshold Limit Value, and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the MSDS, where available.
- Whether the hazardous chemical is listed in the National Toxicology Program (NTP) Annual Report on Carcinogens (latest edition) or has been identified as a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs (latest editions) or by OSHA.
- Any generally applicable precautions for safe handling and use which are known to the chemical manufacturer, importer, or employer preparing the MSDS, including appropriate hygienic practices, protective measures during repair and maintenance of contaminated equipment, and procedures for clean-up of spills and leaks.
- Any generally applicable control measures which are known to the chemical manufacturer, importer or employer preparing the MSDS, such as appropriate engineering controls, work practices, or personal protective equipment.
- Emergency and first aid procedures.
- The date of preparation of the MSDS or the last change to it.
- The name, address, and telephone number of the chemical manufacturer, importer, employer or other responsible party preparing or distributing the MSDS, who can provide additional information on the hazardous chemical and appropriate emergency procedures, if necessary.

Mixture: As defined by OSHA (29 CFR 1910.1200), any combination of two or more chemicals if the combination is not, in whole or in part, the result of a chemical reaction.

Occupational Safety and Health Act: Federal statute that governs workplace safety and the exposure of workers to chemicals in the workplace.

Occupational Safety and Health Administration (OSHA): A federal agency under the United States Department of Labor which develops and administers industrial safety and health standards.

Organic Peroxide: As defined by OSHA (29 CFR 1910.1200), an organic compound that contains the bivalent -O-O-structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

Oxidizer: As defined by OSHA (29 CFR 1910.1200), a chemical other than a blasting agent or explosive as defined in 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

Permissible Exposure Limit (PEL): An enforceable standard promulgated by OSHA. The PEL for a substance is the 8-hour TWA or ceiling concentration above which workers may not be exposed. Although personal protective equipment may not be required for exposures below the PEL, its use may be advisable where there is a potential for overexposure. In many cases, PELs are derived from TLVs published in 1968.

Personal Protective Equipment (PPE): Any material or device worn to protect a worker from exposure to or contact with any harmful substance or force.

Physical Hazard: As defined by OSHA (29 CFR 1910.1200), a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive.

Pyrophoric: As defined by OSHA (29CFR 1910.1200), a chemical that will ignite spontaneously in air at a temperature of 130 ^{o}F (54.4 ^{o}C) or below.

Reactive: Readily susceptible to chemical change and the possible release of energy; unstable. For example, as defined by OSHA (29 CFR 1910.1200), water-reactive means a chemical will react with water to release a gas that is either flammable or presents a health hazard.

Recommended Exposure Limit (REL): The workplace exposure concentration recommended by the National Institute for Occupational Safety and Health (NIOSH) for promulgation by OSHA as a PEL, but not enforceable as is the OSHA PEL. Typical units are parts per million (ppm).

Sensitizer: As defined by OSHA (29 CFR 1910.1200), a chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical.

Threshold Limit Value (TLV): The airborne concentration of a substance representing a condition under which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect. Air at such a value may be breathed continually for 8 hours per day and 40 hours per week without harm. Because of wide variation in individual susceptibility,

exposure of an occasional individual at or even below the TLV may not prevent discomfort, aggravation of a preexisting condition, or occupational illness. This is also referred to as the threshold limit value - time-weighted average (TLV-TWA). Typical units are ppm.

Threshold Limit Value - Ceiling (TLV-C): The concentration that should not be exceeded even instantaneously. Typical units are ppm.

Threshold Limit Value - Short-Term Exposure Limit (TLV-STEL): A 15-minute TWA exposure that should not be exceeded at any time during the work day. Typical units are ppm.

Upper Explosive Limit (UEL): The maximum proportion of vapor or gas in air above which propagation of flame does not occur. The upper limit of the flammable or explosive range. See also LEL.

APPROACH/METHODOLOGY: The following presents a summary of the approach or methodology for assessing the process safety of chemical substitutes, processes, and/or technologies. Methodology details for Steps 5, 6, 8, and 9 follow this section.

Step 1: Obtain a MSDS for the chemical products in the use cluster, noting properties of the products, fire and explosion hazard data, reactivity data, precautions for safe handling and use, and control measures. In DfE pilot projects, chemical suppliers have provided MSDSs for the chemical products evaluated in the Performance Assessment. If an MSDS is not available, or a MSDS has not yet been generated for a new substitute chemical product, the information contained within an MSDS should be developed to adequately assess the potential safety hazards of a substitute. (See the resources listed in the Published Guidance on Process Safety, Table 5-19, and Sources of Process Safety Data, Table 5-20.)

Step 2: If a MSDS is not available for a substitute, obtain chemical identities, including CAS RNs and synonyms, and chemical properties for individual chemicals, such as reactivity and flashpoint, from the Chemical Properties module.

Step 3: Obtain the process description and process flow diagram from the Chemistry of Use & Process Description module.

Step 4: Obtain a description of worker activities and workplace practices from the Workplace Practices & Source Release Assessment module.

Step 5: Compare MSDS data against the process description and workplace practices to determine if the substitute chemical might pose a safety hazard.

Step 6: Determine and list special precautions or actions that should be taken if a substitute is used that presents a safety hazard. This information could affect the feasibility or the cost of the process and therefore, whether or not to use that particular substitute.

Step 7: If a substitute is considered a hazardous chemical, refer to OSHA 29 CFR 1910.119 to determine the process safety management of that substitute. This would include using hazard evaluation techniques such as what-if scenarios, checklists, hazard and operability study (HAZOP), failure mode and effects analysis (FMEA), and other analyses. Appendix A to 1910.119 also contains a list of highly hazardous chemicals, toxics, and reactives. (Also refer to Table 5-10 for other sources of published guidance.)

Step 8: Review OSHA regulations to determine and list safe operating procedures, including safe start-up and shut-down procedures, that apply to the baseline or to the substitutes.

Step 9: Provide results of the Process Safety Assessment module to the Cost Analysis and the Risk, Competitiveness, & Conservation Data Summary modules.

METHODOLOGY DETAILS: This section presents the methodology details or examples for completing Steps 5, 6, 8, and 9 above.

Details: Step 5, Comparing MSDS Data with the Process Description and Workplace Practices

The following are examples of chemical properties that may be incompatible with certain operating conditions:

- Flammable chemicals used in an area where welding occurs.
- Flammable chemicals used in a process that operates at elevated temperatures near the chemical flashpoint.
- Water-reactive chemicals used in an area where aqueous spray washing occurs.
- Water-reactive chemicals used in a humid environment where water condenses on chilled equipment.

Details: Step 6, Determining or Listing Special Precautions or Actions to be Taken if Substitute is Used

Examples of special precautions include the following storage conditions:

- Flammable liquids, which should be stored in flammable liquid storage cabinets or refrigerators.
- Caustics, which should not be stored next to acids.

- Oxidizers, which should be stored separately from flammable and combustible materials as well as reducing agents (some oxidizers, such as perchloric acid, must be used only in a water wash-down fume hood made of stainless steel).
- Peroxide-forming compounds, which should be stored in airtight containers in a dark, cool, dry area.
- Compressed gases, which should be stored in a locked, upright position and contained within gas cylinders in a dry, cool location away from fumes, direct and indirect heat or flames.
- Chemicals that are highly flammable or corrosive (hazardous gases must be stored and used in fume hoods or ventilated cabinets and adequate PPE should be used).

Other examples of special precautions to be taken if a substitute presents a safety hazard are the use of chemical protective clothing and respirators. Specific examples warranting the use of chemical protective clothing include:

- Handling liquid chemicals during electronic component manufacture.
- Maintenance and quality assurance activities for chemical production.
- Application of pesticides and other agricultural chemicals.
- Chemical waste handling and emergency chemical spill response.

Specific examples warranting the use of respirators include:

- While engineering controls are being installed or tested.
- While engineering controls are being repaired or maintained; during fire fighting activities.
- During escape from suddenly occurring hazardous atmospheres.
- To eliminate hazardous conditions associated with emergencies.
- For operations where other controls are not feasible.
- For certain short-term operations where installing engineering controls would be economically impractical.

Details: Step 8, Reviewing OSHA Safe Operating Procedures

OSHA has established safe operating procedures that are either industry-specific or apply to the operation of equipment in numerous industry sectors. An example of a widely applicable OSHA standard is 29 CFR 1910.147, the OSHA standard entitled "The Control of Hazardous Energy (Lockout/Tagout)." This standard covers the servicing and maintenance of machines and equipment in which the unexpected energization or start-up of the machines or equipment, or release of stored energy could cause injury to employees. For some types of equipment the standard permits "tagout" or placement of a tagout device on an energy isolating device in accordance with established procedure to warn that equipment may not be operated if the employer can demonstrate that using the tagout will provide full employee protection.

Details: Step 9, Providing Results of the Process Safety Assessment to the Cost Analysis and the Risk, Competitiveness & Conservation Data Summary Modules

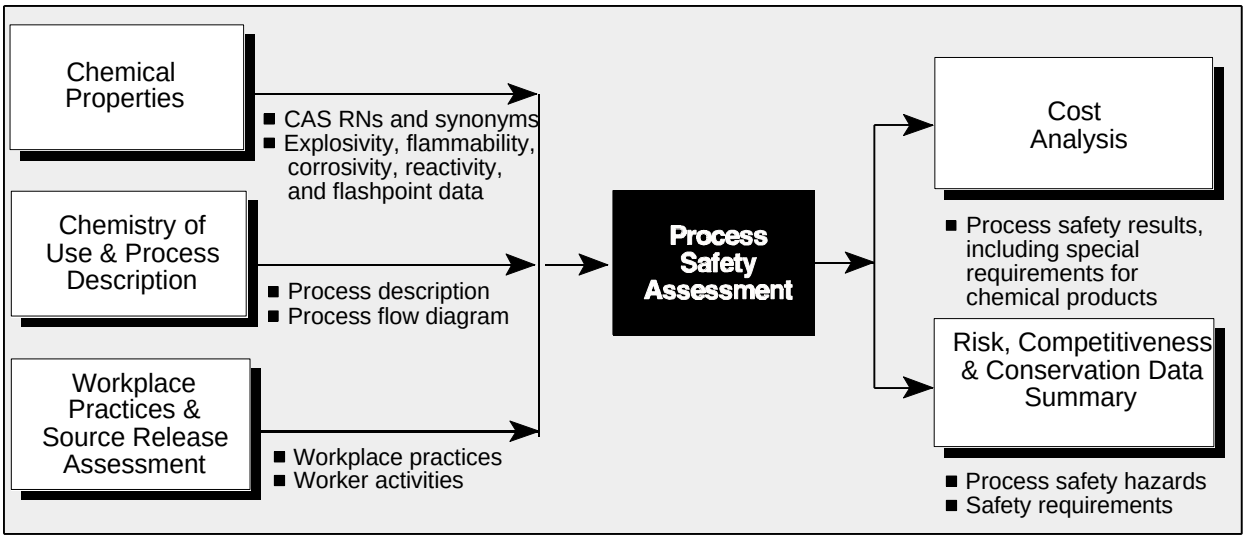
Table 5-18 indicates the type of information transferred from the Process Safety Assessment module.

TABLE 5-18: DATA TRANSFERRED FROM THE PROCESS SAFETY ASSESSMENT MODULE

Module	Data Transferred
Cost Analysis	Whether or not substitute requires special equipment which must be purchased. (Examples would include flammable liquid storage cabinets, fume hoods, ventilated cabinets, and PPE.)
Risk, Competitiveness & Conservation Data Summary	Corrosivity, explosivity, flammability possibilities and whether or not substitute is a hazardous chemical or substance, and a comparison of all substitutes to assess differences in physical or mechanical hazards.

FLOW OF INFORMATION: In a CTSA, this module receives data from the Chemical Properties, Chemistry of Use & Process Description, and Workplace Practices & Source Release Assessment modules. The Process Safety Assessment module transfers data to the Cost Analysis and the Risk, Competitiveness & Conservation Data Summary modules. Example information flows are shown in Figure 5-9.

FIGURE 5-9: PROCESS SAFETY ASSESSMENT MODULE: EXAMPLE INFORMATION FLOWS



ANALYTICAL MODELS: None cited.

PUBLISHED GUIDANCE: Table 5-19 presents references for published guidance on process safety.

TABLE 5-19: PUBLISHED GUIDANCE ON PROCESS SAFETY

Reference	Type of Guidance
American Petroleum Institute. UNDATED. *Management of Process Hazards.*	Describes recommended practices to prevent or minimize process hazards.
Dow Chemical Company. 1987. *Dow's Fire and Explosion Index Hazard Classification Guide.*	Helps the user quantify the expected damage of potential fire and explosion incidents; identifies equipment likely to contribute to the creation or escalation of an incident; and communicates fire and explosion risk potential to management.
National Safety Council. UNDATEDa. *Accident Prevention Manual for Industrial Operations.*	Three volumes containing accident prevention information concerning administration, engineering and technology, and environmental issues.
National Safety Council. UNDATEDb. *Fundamentals of Industrial Hygiene.*	Illustrated reference covers monitoring, evaluation, and control of workplace health hazards. It deals with OSHA regulations, professional standards, exposures, and worker's right to know laws.
National Safety Council. 1983. *Accident Investigation. . . A New Approach.*	Includes a seven-point program to cover environmental issues. Defines the components of a comprehensive program and of regulatory compliance.
Stull, D.R., Ed. UNDATED. *Fundamentals of Fire and Explosion.*	Reviews the fundamentals of fire and explosion. Topics include thermochemistry; kinetochemistry; ignition (gases, liquids, and solids); flames and dust explosions; thermal explosions; gas phase detonations; condensed phase detonations; evaluating reactivity hazard potential; blast effects, fragments and craters; and protection against explosions.
Texas Chemical Council. UNDATED. *Recommended Guidelines for Contractor Safety and Health.*	Includes a comprehensive model for a contractor safety and health program in the chemical industry. Describes responsibilities, safety requirements, safety and health training, safety program, substance abuse, safety audit, and accident reporting.

TABLE 5-19: PUBLISHED GUIDANCE ON PROCESS SAFETY	
Reference	**Type of Guidance**
U.S. Department of Labor, Occupational Safety and Health Administration. UNDATEDa. *The Control of Hazardous Energy (Lockout/Tagout), 29 CFR 1910.147.*	Describes the OHSA regulations for the servicing and maintenance of machines and equipment in which the unexpected energization or start-up of the machines or equipment, or release of stored energy could cause injury to employees.
U.S. Department of Labor, Occupational Safety and Health Administration. UNDATEDb. *Process Safety Management of Highly Hazardous Chemicals, 29 CFR 1910.119.*	Describes the OSHA regulations for process safety management of highly hazardous chemicals.
U.S. Department of Labor, Occupational Safety and Health Administration. UNDATEDc. *Regulations Relating to Labor, 29 CFR 1926.64, Subpart D -- Occupational Health and Environmental Controls*.	Describes the OSHA regulations for preventing or minimizing the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals.
U.S. Department of Labor, Occupational Safety and Health Administration. UNDATEDd. *Regulations Relating to Labor, 29 CFR 1910, Subpart Z -- Toxic and Hazardous Substances*.	Describes the OSHA regulations for hazard communication.
U.S. Department of Labor, Occupational Safety and Health Administration. UNDATEDe. *Training Requirements in OSHA Standards and Training Guidelines*.	Describes OSHA training guidelines and requirements for general industry, maritime, construction, agricultural, and federal employees.
U.S. Department of Labor, Occupational Safety and Health Administration. 1970. *Occupational Safety and Health Act of 1970, Public Law No. 91-596.*	Describes original OSHA statute.
U.S. Department of Labor, Occupational Safety and Health Administration. 1986. *Safety & Health Guide for the Chemical Industry*.	Contains guidelines used by OSHA compliance officers to evaluate employer safety programs, particularly in the areas of disaster prevention and emergency response.
U.S. Department of Labor, Occupational Safety and Health Administration. 1989b. *Chemical Hazard Communication*.	Contains a summary of the OSHA Hazard Communication Standard.
U.S. Department of Labor, Occupational Safety and Health Administration. 1993. *Process Safety Management Guidelines for Compliance*.	Describes a systematic approach to designing a process safety management program.
U.S. Department of Transportation. UNDATED. *Hazardous Materials Transportation Regulations, 49 CFR 100 to 177*.	Lists and describes hazardous materials as well as requirements for shipping, labeling, and transporting hazardous materials.

TABLE 5-19: PUBLISHED GUIDANCE ON PROCESS SAFETY	
Reference	**Type of Guidance**
U.S. Department of Transportation. 1994. *Emergency Response Guide.*	Lists chemicals which are health hazards and the emergency measures needed in the events of fire, explosion, injury, spills, and accidental releases.

Note: References are listed in shortened format, with complete references given in the reference list following Chapter 10.

DATA SOURCES: Table 5-20 lists sources of process safety data.

TABLE 5-20: SOURCES OF PROCESS SAFETY DATA	
Reference	**Type of Data**
Hazardous Chemicals Data Book. 1986.	Includes the following data on certain hazardous chemicals: chemical description, fire and explosion hazards, life hazards, personal protection needed, fire fighting measures, usual shipping containers, storage information, and special remarks regarding electrical installations and NFPA code numbers pertaining to the specified chemical.
Merck Index. 1989.	Handbook containing some caution and/or human toxicity statements for some substances.
National Fire Protection Association. 1995. *Fire Protection Guide on Hazardous Materials.*	Includes complete text of four different fire codes. Also includes chemical hazard data, quantitative health hazard rating based on recent research, and information needed on handling and storage of hazardous chemicals.
NIOSH/OSHA Pocket Guide to Chemical Hazards. 1995.	Lists known hazardous chemicals along with their health hazards, exposure limits, chemical and physical properties, incompatibilities, and suggested PPE, including recommended respirators.

TABLE 5-20: SOURCES OF PROCESS SAFETY DATA	
Reference	**Type of Data**
Sax, N. Irving and Richard J. Lewis, Sr. 1989. *Dangerous Properties of Industrial Materials*.	A three-volume set containing hazard information. Volume I contains essays on selected topics relating to hazardous materials, a CAS RN cross-index, a synonym cross-index, and the list of CODEN bibliographic references given in the data section. Volumes II and III list and describe more than 20,000 materials in alphabetical order by entry name. Descriptions include physical and chemical properties, clinical data on experimental animals and humans, a material's hazard potential, IARC Cancer Review and the U.S. National Toxicology Program cancer testing program conclusions, OSHA PELs, ACGIH TLVs, and NIOSH RELs, DOT classifications, and Toxic and Hazardous Reviews (THRs). Fire and explosion hazards are briefly summarized.
Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment. UNDATED.	Lists TLVs for many chemicals found in the workplace.

Note: References are listed in shortened format, with complete references given in the reference list following Chapter 10.